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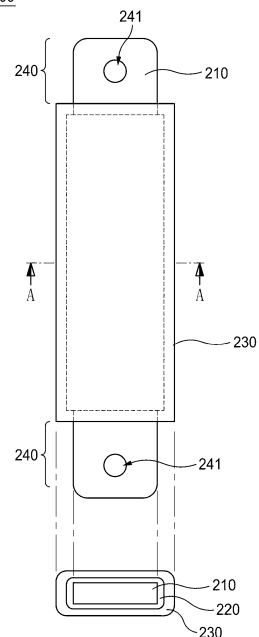
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(54) **INTERMODULAR BUSBAR INCLUDING INSULATING LAYER AND BATTERY PACK INCLUDING SAME**

(57) The present invention relates to an inter-module busbar including a metal plate for electrical connection, a first insulating layer configured to enclose at least a part of the metal plate, the first insulating layer being expandable at high temperatures, and a second insulating layer added to the first insulating layer, the second insulating layer being configured to be ceramized at high temperatures, wherein the metal plate in the busbar is not exposed in the event of fire, whereby short circuit due to contact with the metal plate may be prevented.

【FIG. 2】
200



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Description

[Technical Field]

[0001] This application claims the benefit of priority to Korean Patent Application No. 2022-0111786 filed on September 5, 2022, the disclosure of which is incorporated herein by reference in its entirety.

[0002] The present invention relates to an inter-module busbar including an insulating layer and a battery pack including the same. More particularly, the present invention relates to an inter-module busbar configured such that an insulated state of the inter-module busbar is maintained even when fire breaks out in a battery pack, whereby it is possible to prevent short circuit even when in contact with a peripheral portion, and a battery pack including the same.

[Background Art]

[0003] There is growing demand for secondary batteries capable of addressing air pollution caused by the use of fossil fuels and storing electrical energy generated from alternative energy. For example, a lithium secondary battery, which has high energy density per weight, is being used as an energy source not only for mobile devices, such as a cellular phone, a tablet, a Bluetooth earphone, and an electronic cigarette, but also for medium and large-sized devices, such as an electric bicycle, an electric kickboard, and electric vehicles.

[0004] As the kinds of devices using the lithium secondary battery as an energy source increase, application of the lithium secondary battery to devices that require high capacity and high power has expanded.

[0005] In line with this trend, there has been an increase in manufacture and use of a battery module, in which a plurality of battery cells is electrically connected to each other, and a battery pack, in which battery modules are connected to each other in series and/or parallel.

[0006] Meanwhile, an inter-module busbar is widely used as a means for electrical connection between battery cells in the battery module and a means for electrical connection between battery modules in the battery pack. The inter-module busbar is useful as a large current conduction means since the inter-module busbar is capable of allowing large current to stably flow therethrough even with a relatively small thickness compared to a cable.

[0007] Generally, the inter-module busbar may be used in a form in which a metal plate including copper or aluminum having excellent electrical conductivity is disposed inside and the remaining part of the outer surface of the metal plate, excluding opposite ends of the metal plate at which coupling is performed to secure electrical insulation, is covered with a tube or an injection-molded product.

[0008] In connection therewith, FIG. 1 is a perspective view showing a conventional inter-module busbar before and after damage by fire.

[0009] An inter-module busbar is used for electrical connection between battery modules, and FIG. 1 shows the structure of the inter-module busbar and the state in which the inter-module busbar is damaged by fire.

[0010] Referring to FIG. 1, the conventional inter-module busbar includes a metal plate 110 made of an electrically conductive material, an insulating tape 120 configured to enclose the remaining part of an outer surface of the metal plate 110 excluding opposite ends thereof, and a silicone tube 130 added to an outer surface of the insulating tape 120.

[0011] Each of the insulating tape 120 and the silicone tube 130 is made of an electrically insulating material, and therefore it is possible to secure insulation of configurations of the inter-module busbar other than a device coupled to opposite ends of the inter-module busbar.

[0012] When a battery cell in a battery pack ignites or explodes, thermal energy of the battery cell is transferred to neighboring cells, causing fire. When the silicone tube 130 of the inter-module busbar, which connects battery modules to each other, is damaged by fire in the battery cell, the insulation tape 120 may open up, whereby the metal plate 110 inside may be exposed.

[0013] When the exposed metal plate comes into contact with a structure of the battery pack, short circuit may occur, and such internal short circuit may form an electrical closed circuit in the battery pack, which may accelerate thermal runaway in the battery pack.

[0014] In connection therewith, Patent Document 1 discloses a busbar including a metal bar made of a metal material, an insulative tube configured to cover the remaining part of the metal bar excluding opposite ends thereof, a fireproof tape configured to enclose the metal bar in the insulative tube, and a bandage member made of a fire-resistant material and interposed between the insulative tube and the fireproof tape, the bandage member being configured to fix the fireproof tape to the metal bar in a state of enclosing the fireproof tape.

[0015] In Patent Document 1, the fireproof tape is strongly fixed by the bandage member even though the insulative tube is burned away by fire, whereby it is possible to prevent the metal bar from directly contacting a surrounding metal object and thus to prevent short circuit.

[0016] Patent Document 2 discloses a busbar including a metal bar made of a metal material, a bandage member configured to enclose the remaining part of the metal bar excluding opposite ends thereof, and an insulative tube configured to enclose both the metal bar and the bandage member.

[0017] In Patent Document 2, the bandage member on the surface of the metal bar remains attached to the surface of the metal bar even in the event of fire, whereby the metal bar does not directly contact a surrounding metal object, and therefore it is possible to prevent short circuit.

[0018] However, each of the busbars of Patent Document 1 and Patent Document 2 further includes a bandage member, whereby the thickness and weight of the

busbar may be increased.

[0019] Therefore, there is a need for an inter-module busbar configured such that an increase in volume and weight of the inter-module busbar is minimized while exposure of a metal material inside is prevented even though an insulating material added to an outer surface of the busbar is burned away by fire.

(Prior Art Documents)

[0020]

(Patent Document 1) Korean Patent Application Publication No. 2021-0050983 (2021.05.10)

(Patent Document 2) Korean Patent Application Publication No. 2021-0141095 (2021.11.23)

[Disclosure]

[Technical Problem]

[0021] The present invention has been made in view of the above problems, and it is an object of the present invention to provide an inter-module busbar configured such that a metal plate inside is not exposed even though a second insulating layer, which is an outer surface, is ceramized and cracked in the event of fire, whereby it is possible to prevent short circuit caused by contact with a surrounding metal object.

[Technical Solution]

[0022] An inter-module busbar according to the present invention to accomplish the above object includes a metal plate for electrical connection, a first insulating layer configured to enclose at least a part of the metal plate, the first insulating layer being expandable at high temperatures, and a second insulating layer added to the first insulating layer, the second insulating layer being configured to be ceramized at high temperatures.

[0023] The first insulating layer may include expandable flame-retardant silicone.

[0024] The second insulating layer may include at least one selected from the group consisting of highly heat-resistant silicone, polyphenylene sulfide, polyetheretherketone, polyphthalamide, polyamide, polysulfone, polyethersulfone, polyetherimide, acrylic fiber, and polybenzimidazole.

[0025] The second insulating layer may be ceramized at a temperature of at least 1,200°C.

[0026] When the second insulating layer is ceramized and cracks are formed in the second insulating layer due to an increase in temperature, the first insulating layer may expand and may be inserted into the cracks to fill spaces in the cracks.

[0027] When the first insulating layer expands, the metal plate in the first insulating layer and the second insulating layer may not be exposed.

[0028] The first insulating layer and the second insulating layer may not be added to opposite ends of the metal plate, and the metal plate may be exposed to constitute an electrical connection portion.

5 **[0029]** The electrical connection portion may be provided with at least one opening for connection.

[0030] The present invention provides a battery pack including battery modules electrically connected using the inter-module busbar.

10 **[0031]** The battery pack may include a battery pack housing configured to receive two or more battery modules, a pack frame configured to allow the battery modules to be disposed in spaces partitioned therein in order to position the battery modules, and an inter-module busbar configured to electrically connect the battery modules to each other, wherein the inter-module busbar may be disposed such that a first insulating layer and a second insulating layer are located at an upper surface of the pack frame, and electrical connection portions provided at opposite ends of the inter-module busbar to which the first insulating layer and the second insulating layer are not added may be coupled to connectors of the battery modules.

20 **[0032]** When the second insulating layer is ceramized and the first insulating layer expands due to an increase in temperature of the pack frame, the insulated state of the inter-module busbar may be maintained while the metal plate is not exposed in the state in which the inter-module busbar is in contact with the pack frame.

30 **[0033]** In addition, the present invention may provide various combinations of the above solving means.

[Advantageous Effects]

35 **[0034]** As is apparent from the above description, an inter-module busbar according to the present invention is configured such that, even though a second insulating layer is ceramized and cracked in the event of fire, a first insulation layer, which is expandable at high temperatures, penetrates into the cracks in the second insulation layer and fills gaps therein, whereby it is possible to prevent a metal plate from being exposed.

40 **[0035]** In the event of fire, therefore, it is possible to secure insulation of the busbar even though the busbar remains in contact with a surrounding metal object.

[Description of Drawings]

[0036]

FIG. 1 is a perspective view showing a conventional inter-module busbar before and after damage by fire. FIG. 2 is a plan view and a vertical sectional view of an inter-module busbar according to the present invention.

55 FIG. 3 is a vertical sectional view showing the inter-module busbar according to the present invention before and after damage by fire.

FIG. 4 is a perspective view of a battery pack including the inter-module busbar of FIG. 2.

[Best Mode]

[0037] Now, preferred embodiments of the present invention will be described in detail with reference to the accompanying drawings such that the preferred embodiments of the present invention can be easily implemented by a person having ordinary skill in the art to which the present invention pertains. In describing the principle of operation of the preferred embodiments of the present invention in detail, however, a detailed description of known functions and configurations incorporated herein will be omitted when the same may obscure the subject matter of the present invention.

[0038] In addition, the same reference numbers will be used throughout the drawings to refer to parts that perform similar functions or operations. In the case in which one part is said to be connected to another part throughout the specification, not only may the one part be directly connected to the other part, but also, the one part may be indirectly connected to the other part via a further part. In addition, that a certain element is included does not mean that other elements are excluded, but means that such elements may be further included unless mentioned otherwise.

[0039] In addition, a description to embody elements through limitation or addition may be applied to all inventions, unless particularly restricted, and does not limit a specific invention.

[0040] Also, in the description of the invention and the claims of the present application, singular forms are intended to include plural forms unless mentioned otherwise.

[0041] Also, in the description of the invention and the claims of the present application, "or" includes "and" unless mentioned otherwise. Therefore, "including A or B" means three cases, namely, the case including A, the case including B, and the case including A and B.

[0042] Hereinafter, embodiments of the present invention will be described in detail with reference to the drawings.

[0043] An inter-module busbar according to the present invention is a type of busbar used as an electrical connection means, and refers to a means configured to interconnect battery modules disposed in a battery pack.

[0044] Consequently, it is possible to set the length of the inter-module busbar in consideration of the distance between battery modules to be connected and to set the width and thickness of the inter-module busbar in consideration of the amount of current that passes through the inter-module busbar and the resistance of the inter-module busbar.

[0045] In addition, the shape of the inter-module busbar may be configured in consideration of the positions of connectors of the battery modules, and the inter-module busbar may have various shapes, such as a shape

in which the inter-module busbar is bent upwards or downwards so as to be parallel to the overall width, an L-shape in which the inter-module busbar is bent by 90 degrees in the plane, a J-shape in which the inter-module busbar is bent at opposite ends thereof in the plane, and a LT-shape.

[0046] Since each of the opposite ends of the inter-module busbar is usually used as a connection portion for coupling to an external device, a structure for connection, such as a fastening hole for bolt fastening, is provided.

[0047] FIG. 2 is a plan view and a vertical sectional view of an inter-module busbar according to the present invention, wherein a section taken along A-A in the plan view at an upper part of FIG. 2 is shown as a vertical sectional view at a lower part of FIG. 2.

[0048] Referring to FIG. 2, the inter-module busbar 200 includes a metal plate 210 for electrical connection, a first insulating layer 220 configured to enclose at least a part of the metal plate 210, the first insulating layer being expandable at high temperatures, and a second insulating layer 230 added to the first insulating layer 220, the second insulating layer being configured to be ceramized at high temperatures.

[0049] The first insulating layer 220 and the second insulating layer 230 are not added to opposite ends of the metal plate 210, and the ends of the metal plate 210 are exposed to constitute electrical connection portions 240.

[0050] At least one opening 241 for connection is formed in each of the electrical connection portions 240.

[0051] One of the electrical connection portions 240 formed at the opposite ends of the inter-module busbar 200 may be connected to a positive electrode connector of a first battery module, and the other may be connected to a negative electrode connector of a second battery module. Specifically, when a bolting operation utilizing bolts and nuts is performed such that the inter-module busbar is connected to the connectors of the battery modules, the bolts may be inserted into the openings 241 and the nuts may be fastened to the bolts, whereby the inter-module busbar 200 may be connected to the first battery module and the second battery module.

[0052] The second insulating layer 230 constitutes the outermost surface with which flames come into direct contact in the event of fire, and therefore the second insulating layer may include at least one selected from the group consisting of highly heat-resistant silicone, polyphenylene sulfide, polyetheretherketone, polyphthalamide, polyamide, polysulfone, polyethersulfone, polyetherimide, acrylic fiber, and polybenzimidazole.

[0053] Specifically, the second insulating layer 230 may be highly heat-resistant silicone which is ceramized and in which small cracks are formed when exposed to flames or high-temperature gases.

[0054] The highly heat-resistant silicone exhibits the performance of a general silicone resin at room temperature, but at high temperatures, the structure of the highly

heat-resistant silicone is changed to a ceramized structure, whereby the highly heat-resistant silicone has ceramic properties, and therefore the highly heat-resistant silicone may withstand impact while maintaining certain strength.

[0055] The second insulating layer 230 may be made of a material that is ceramized at high temperatures, and may be ceramized, for example, at 1,200°C or higher.

[0056] Consequently, the shape of the second insulating layer may be maintained and the second insulating layer may exhibit flame resistance below 1,200°C. However, the second insulating layer may be ceramized and cracked at 1,200°C or higher.

[0057] When a battery cell in a battery pack ignites and explodes and heat is transferred to the inter-module busbar coupled to the battery modules, the second insulating layer may be ceramized by gas or flames discharged from the battery cell, but the shape of the second insulating layer may be maintained.

[0058] Consequently, it is possible to prevent a conventional problem in which, when a silicone tube is added to an outer surface of a metal plate, the silicone tube is burned away, whereby the metal plate is exposed.

[0059] The first insulating layer 220 may include expandable flame-retardant silicone that is expandable at high temperatures.

[0060] The thermal expansion temperature of the first insulating layer 220 may be higher than the temperature at which the second insulating layer 230 is ceramized.

[0061] That is, when a high-temperature environment is formed due to fire, the second insulating layer is ceramized and cracked. When flames or venting gases penetrate through the cracks and come into contact with the first insulating layer, the first insulating layer, which is expandable at high temperatures, expands and fills gaps between the cracks. As described above, the metal plate is not exposed to the outside at the parts to the first and second insulating layers of the inter-module busbar are added, and therefore it is possible to secure insulation.

[0062] FIG. 3 is a vertical sectional view showing the inter-module busbar according to the present invention before and after damage by fire.

[0063] FIG. 3 shows three steps of a process in which the inter-module busbar is damaged by fire, wherein time progresses from top to bottom.

[0064] Referring to the first figure of FIG. 3, which is a vertical sectional view of a normal inter-module busbar 200 in which no fire breaks out, an outer surface of the innermost metal plate 210 is sequentially enclosed by the first insulating layer 220, which is expandable at high temperatures, and the second insulating layer 230, which is ceramized at high temperatures.

[0065] Referring to the second figure of FIG. 3, when fire breaks out in the battery cell, flames or high-temperature gases are transferred to the inter-module busbar, whereby the second insulating layer 230, which is the outermost layer, is ceramized and cracked, and the first

insulating layer 220 and the outside of the second insulating layer 230 communicate with each other through the cracks.

[0066] Referring to the third figure of FIG. 3, when the second insulating layer 230 is ceramized and cracked when the temperature increases, high-temperature gases and flames are transferred to the first insulating layer 220 through the cracks, whereby the first insulating layer 220 expands and is inserted into the cracks to fill spaces in the cracks.

[0067] Since the first insulating layer 220 expands to fill the gaps in the cracks formed in the second insulating layer 230, as described above, the part of the inter-module busbar to which the first insulating layer 220 and the second insulating layer 230 are added may remain enclosed by the first insulating layer 220 and the second insulating layer 230 without communication with the outer surface of the second insulating layer 230.

[0068] When the second insulating layer is ceramized by fire and the first insulating layer expands, therefore, the part of the metal plate in the first insulating layer and the second insulating layer is not exposed.

[0069] FIG. 4 is a perspective view of a battery pack including the inter-module busbar of FIG. 2.

[0070] The battery pack shown in FIG. 4 is configured such that a plurality of battery modules 301 is electrically connected to each other via the inter-module busbar 200 according to the present invention. Although FIG. 4 shows a battery pack including nine battery modules, which is merely an example for illustrative purposes, the arrangement and number of the battery modules constituting the battery pack and the coupling position and shape of the inter-module busbar used to interconnect the battery modules are not limited thereto.

[0071] Referring to FIG. 4, the battery pack 300 according to the present invention includes a battery pack housing 320 configured to receive two or more battery modules 301, a pack frame 310 configured to allow the battery modules 301 to be disposed in spaces partitioned therein in order to position the battery modules, and an inter-module busbar 200 configured to electrically connect the battery modules 301 to each other, wherein the inter-module busbar 200 is disposed such that a first insulating layer and a second insulating layer 230 are located at an upper surface 311 of the pack frame, and electrical connection portions provided at opposite ends of a metal plate 210 to which the first insulating layer and the second insulating layer 230 are not added are coupled to connectors of the battery modules 301.

[0072] Since the second insulating layer 230 of the inter-module busbar 200 is disposed in contact with the pack frame 310, as described above, it is possible to secure insulation between the inter-module busbar 200 and the pack frame 310 in a steady state of the battery pack 300 even though the pack frame 310 is made of an electrically conductive metal material.

[0073] However, when flames or high-temperature gases are discharged from battery cells constituting the

battery pack 300, whereby the temperature of the pack frame 310 increases, the second insulating layer 230 is ceramized, and the first insulating layer 220 expands, insulation of the inter-module busbar 200 may be maintained even in the state in which the inter-module busbar is in contact with the pack frame 310.

[0074] Meanwhile, even when the inter-module busbar is not disposed at the upper surface of the pack frame 310 and the inter-module busbar is disposed in contact with a component constituting the battery pack and made of an electrically conductive metal material, unlike what is shown in FIG. 4, insulation between the inter-module busbar and the component made of the electrically conductive metal material may be maintained in the event of fire in the battery pack.

[0075] In the present invention, as described above, the first insulating layer and the second insulating layer attached to the metal plate are not burned away and remain added to the outer surface of the metal plate in the event of fire. In addition, since the first insulating layer that has expanded fills cracks formed in the second insulating layer, the metal plate may not be exposed to the outside. Therefore, the inter-module busbar may remain insulated even through the inter-module busbar is in contact with a metal component adjacent thereto.

[0076] Those skilled in the art to which the present invention pertains will appreciate that various applications and modifications are possible within the category of the present invention based on the above description.

(Description of Reference Numerals)

[0077]

110, 210: Metal plates
 120: Insulating tape
 130: Silicone tube
 200: Inter-module busbar
 220: First insulating layer
 230: Second insulating layer
 240: Electrical connection portion
 241: Opening
 300: Battery pack
 301: Battery module
 310: Pack frame
 311: Upper surface of pack frame
 320: Battery pack housing

Claims

1. An inter-module busbar comprising:

a metal plate for electrical connection;
 a first insulating layer configured to enclose at least a part of the metal plate, the first insulating layer being expandable at high temperatures;
 and

a second insulating layer added to the first insulating layer, the second insulating layer being configured to be ceramized at high temperatures.

2. The inter-module busbar according to claim 1, wherein the first insulating layer comprises expandable flame-retardant silicone.

3. The inter-module busbar according to claim 1, wherein the second insulating layer comprises at least one selected from a group consisting of highly heat-resistant silicone, polyphenylene sulfide, polyetheretherketone, polyphthalamide, polyamide, polysulfone, polyethersulfone, polyetherimide, acrylic fiber, and polybenzimidazole.

4. The inter-module busbar according to claim 3, wherein the second insulating layer is ceramized at a temperature of at least 1,200°C.

5. The inter-module busbar according to claim 1, wherein, when the second insulating layer is ceramized and cracks are formed in the second insulating layer due to an increase in temperature, the first insulating layer expands and is inserted into the cracks to fill spaces in the cracks.

6. The inter-module busbar according to claim 4, wherein, when the first insulating layer expands, the metal plate in the first insulating layer and the second insulating layer is not exposed.

7. The inter-module busbar according to claim 1, wherein the first insulating layer and the second insulating layer are not added to opposite ends of the metal plate, and the metal plate is exposed to constitute an electrical connection portion.

8. The inter-module busbar according to claim 6, wherein the electrical connection portion is provided with at least one opening for connection.

9. A battery pack comprising battery modules electrically connected using the inter-module busbar according to any one of claims 1 to 8.

10. The battery pack according to claim 9, wherein the battery pack comprises:

a battery pack housing configured to receive two or more battery modules;
 a pack frame configured to allow the battery modules to be disposed in spaces partitioned therein in order to position the battery modules;
 and
 an inter-module busbar configured to electrically connect the battery modules to each other,

wherein

the inter-module busbar is disposed such that a first insulating layer and a second insulating layer are located at an upper surface of the pack frame, and

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electrical connection portions provided at opposite ends of the inter-module busbar to which the first insulating layer and the second insulating layer are not added are coupled to connectors of the battery modules.

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11. The battery pack according to claim 10, wherein, when the second insulating layer is ceramized and the first insulating layer expands due to an increase in temperature of the pack frame, an insulated state of the inter-module busbar is maintained while the metal plate is not exposed in a state in which the inter-module busbar is in contact with the pack frame.

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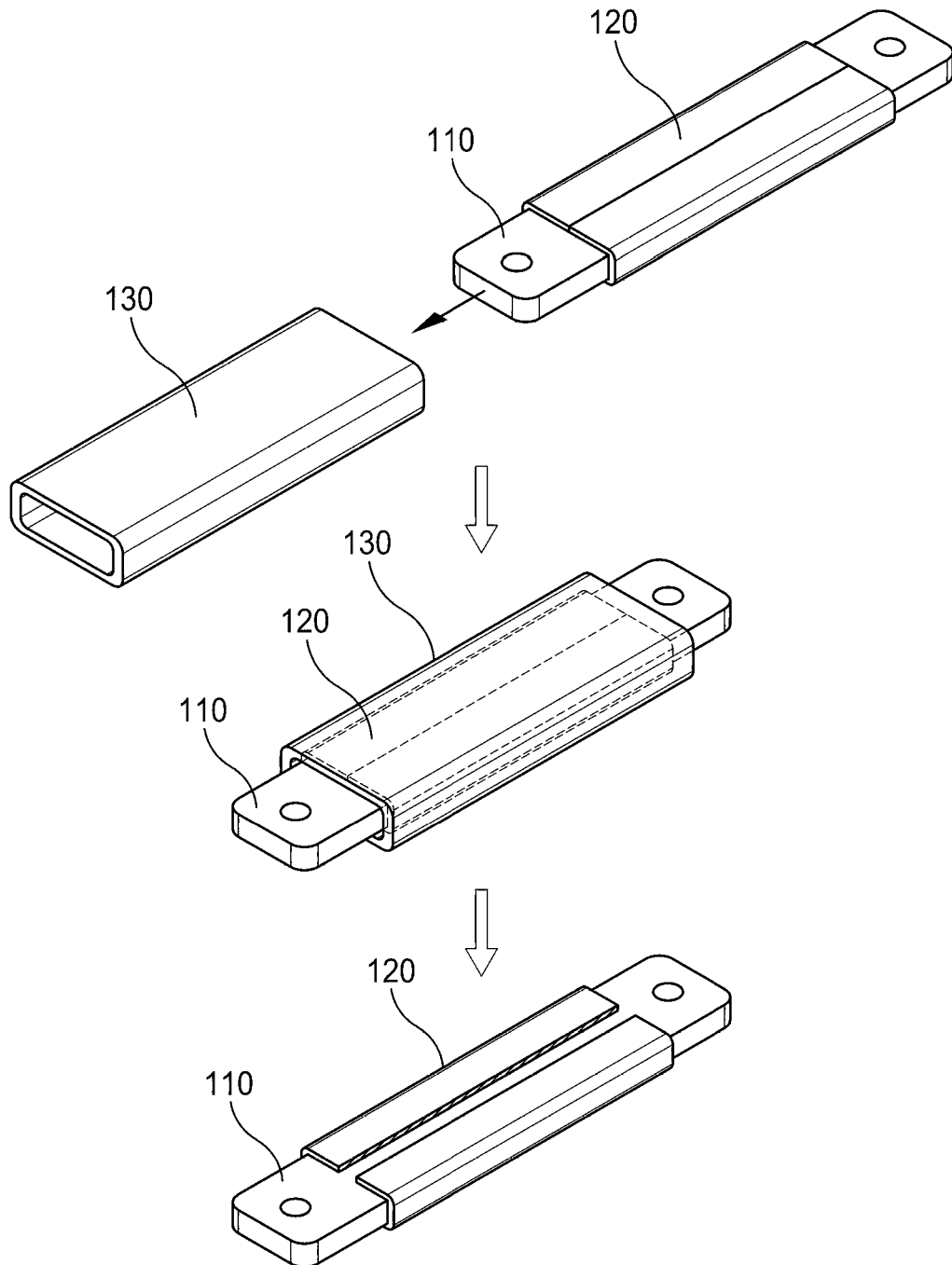
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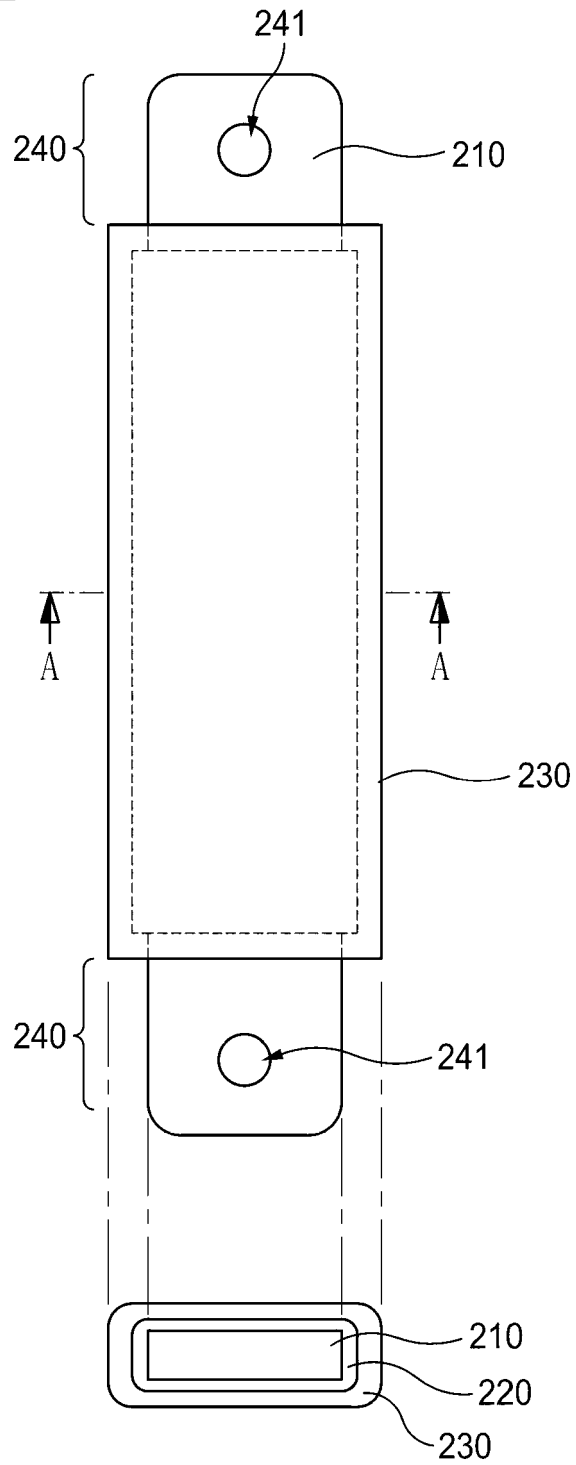
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【FIG. 1】



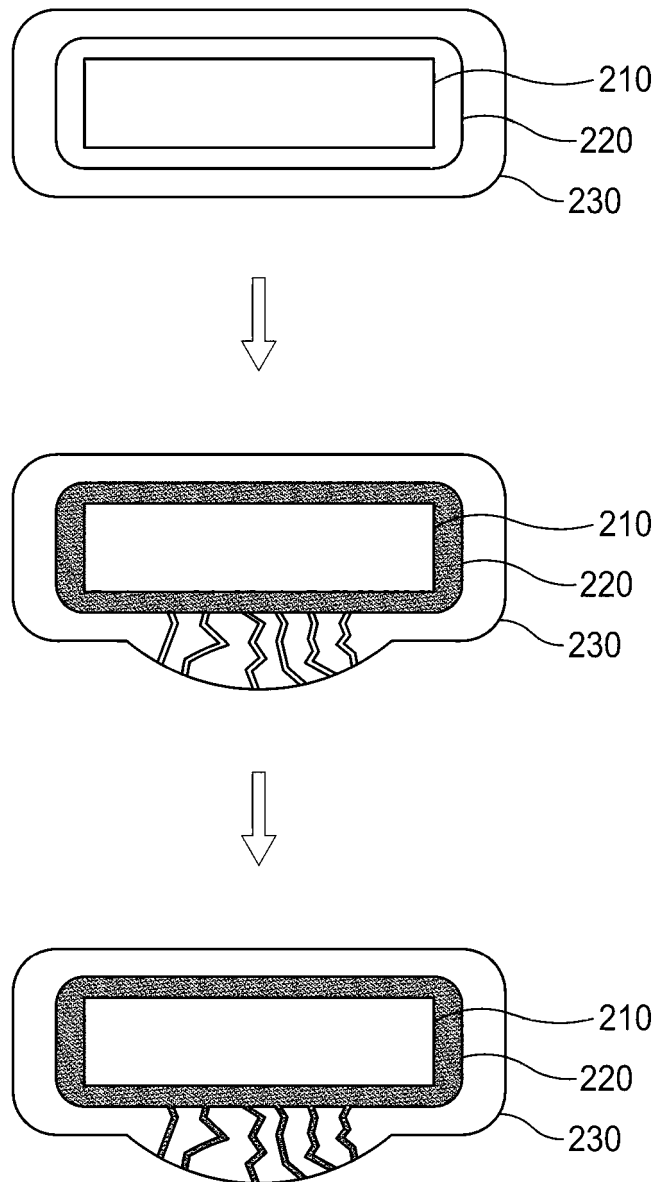
【FIG. 2】

200

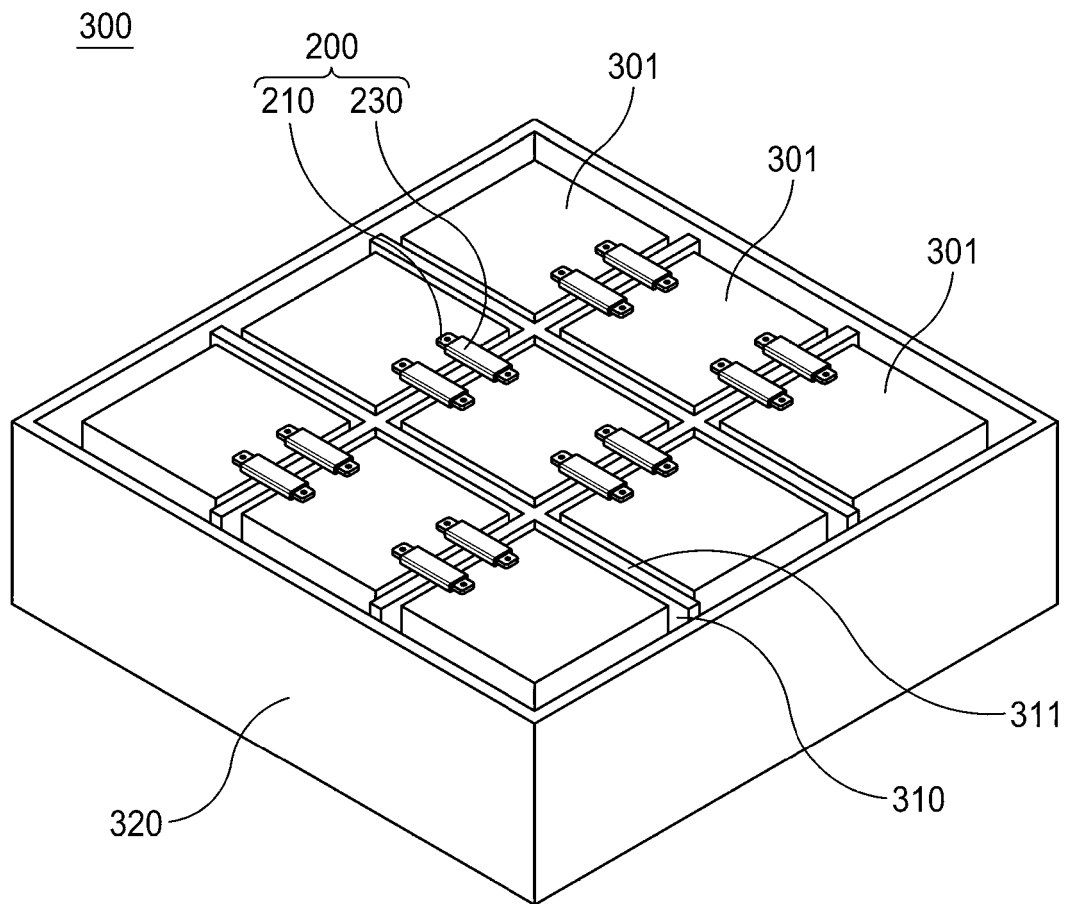


【FIG. 3】

200



【FIG. 4】



INTERNATIONAL SEARCH REPORT

International application No.

PCT/KR2023/011965

A. CLASSIFICATION OF SUBJECT MATTER H01M 50/591(2021.01); H01M 50/503(2021.01); B32B 27/08(2006.01); B32B 27/28(2006.01); B32B 27/34(2006.01); B32B 27/30(2006.01); B32B 1/08(2006.01) According to International Patent Classification (IPC) or to both national classification and IPC																		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) H01M 50/591(2021.01); H01M 10/613(2014.01); H01M 2/20(2006.01); H01M 2/34(2006.01); H01M 50/50(2021.01); H01M 50/543(2021.01); H01R 25/14(2006.01) Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Korean utility models and applications for utility models: IPC as above Japanese utility models and applications for utility models: IPC as above Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) eKOMPASS (KIPO internal) & keywords: 인터 모듈 버스바(inter module busbar), 절연(insulation), 전지팩(battery pack), 팽창(expansion), 세라믹(ceramic), 고온(high temperature)																		
C. DOCUMENTS CONSIDERED TO BE RELEVANT <table border="1"> <thead> <tr> <th>Category*</th> <th>Citation of document, with indication, where appropriate, of the relevant passages</th> <th>Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td>A</td> <td>KR 10-2022-0042795 A (LG ENERGY SOLUTION, LTD.) 05 April 2022 (2022-04-05) See paragraphs [0032] and [0065] and figures 1-4.</td> <td>1-11</td> </tr> <tr> <td>A</td> <td>KR 10-2013-0080023 A (LG CHEM, LTD.) 11 July 2013 (2013-07-11) See claims 1-2 and 4.</td> <td>1-11</td> </tr> <tr> <td>A</td> <td>KR 10-2221801 B1 (SAMSUNG SDI CO., LTD.) 02 March 2021 (2021-03-02) See paragraph [0051] and claim 1.</td> <td>1-11</td> </tr> <tr> <td>A</td> <td>KR 10-2016-0049260 A (LS CABLE & SYSTEM LTD.) 09 May 2016 (2016-05-09) See entire document.</td> <td>1-11</td> </tr> <tr> <td>A</td> <td>CN 108376755 A (GM GLOBAL TECHNOLOGY OPERATIONS LLC) 07 August 2018 (2018-08-07) See entire document.</td> <td>1-11</td> </tr> </tbody> </table>	Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	A	KR 10-2022-0042795 A (LG ENERGY SOLUTION, LTD.) 05 April 2022 (2022-04-05) See paragraphs [0032] and [0065] and figures 1-4.	1-11	A	KR 10-2013-0080023 A (LG CHEM, LTD.) 11 July 2013 (2013-07-11) See claims 1-2 and 4.	1-11	A	KR 10-2221801 B1 (SAMSUNG SDI CO., LTD.) 02 March 2021 (2021-03-02) See paragraph [0051] and claim 1.	1-11	A	KR 10-2016-0049260 A (LS CABLE & SYSTEM LTD.) 09 May 2016 (2016-05-09) See entire document.	1-11	A	CN 108376755 A (GM GLOBAL TECHNOLOGY OPERATIONS LLC) 07 August 2018 (2018-08-07) See entire document.	1-11
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.																
A	KR 10-2022-0042795 A (LG ENERGY SOLUTION, LTD.) 05 April 2022 (2022-04-05) See paragraphs [0032] and [0065] and figures 1-4.	1-11																
A	KR 10-2013-0080023 A (LG CHEM, LTD.) 11 July 2013 (2013-07-11) See claims 1-2 and 4.	1-11																
A	KR 10-2221801 B1 (SAMSUNG SDI CO., LTD.) 02 March 2021 (2021-03-02) See paragraph [0051] and claim 1.	1-11																
A	KR 10-2016-0049260 A (LS CABLE & SYSTEM LTD.) 09 May 2016 (2016-05-09) See entire document.	1-11																
A	CN 108376755 A (GM GLOBAL TECHNOLOGY OPERATIONS LLC) 07 August 2018 (2018-08-07) See entire document.	1-11																
☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex. * Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "D" document cited by the applicant in the international application "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family																		
Date of the actual completion of the international search 16 November 2023	Date of mailing of the international search report 20 November 2023																	
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/KR2023/011965

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
KR 10-2022-0042795 A	05 April 2022	CN 115735299 A	03 March 2023
		EP 4178025 A1	10 May 2023
		JP 2023-528382 A	04 July 2023
		US 2023-0253685 A1	10 August 2023
		WO 2022-065647 A1	31 March 2022
KR 10-2013-0080023 A	11 July 2013	CN 103650209 A	19 March 2014
		CN 103650209 B	17 August 2016
		EP 2698847 A1	19 February 2014
		EP 2698847 B1	04 March 2020
		JP 2014-519153 A	07 August 2014
		KR 10-1463196 B1	21 November 2014
		PL 2698847 T3	15 June 2020
		US 2014-0065467 A1	06 March 2014
		US 9887413 B2	06 February 2018
		WO 2013-103244 A1	11 July 2013
KR 10-2221801 B1	02 March 2021	CN 104821385 A	05 August 2015
		JP 2015-149281 A	20 August 2015
		JP 6593997 B2	23 October 2019
		KR 10-2015-0091791 A	12 August 2015
		US 2015-0221921 A1	06 August 2015
		US 9923183 B2	20 March 2018
KR 10-2016-0049260 A	09 May 2016	None	
CN 108376755 A	07 August 2018	CN 108376755 B	04 June 2021
		DE 102018102074 A1	02 August 2018
		US 10559805 B2	11 February 2020
		US 2018-0219203 A1	02 August 2018

Form PCT/ISA/210 (patent family annex) (July 2022)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- KR 20220111786 [0001]
- KR 20210510 [0020]
- KR 20210050983 [0020]
- KR 20210141095 [0020]